

Best Practices for a 4Gb/s Storage Area Network Infrastructure

Keep application data flowing error-free

Many data centers are in the process of moving from 2Gbit/s (2G) Fibre Channel (FC) infrastructures to the new 4Gbit/s (4G) FC standard. The increase in data transfer rates is instantly beneficial from a performance perspective. However, transitioning to 4G creates some real challenges for architects. In particular, the potential for increased data communication error rates that may result in disruption or performance degradation of business critical applications. The physics of high-speed communication creates many new restrictions on crucial physical-layer elements such as optical cabling and optical modules. These restrictions must be understood, addressed and proactively monitored before the full value of 4G can be realized in today's Storage Area Network (SAN) infrastructures.

As the data rate increases, sensitivity of induced jitter increases

As the speed of Fibre Channel bit rates increase from 1G (1.0625 Gbps) to 2G (2.125 Gbps), now to 4G (4.25 Gbps), and soon to 8G (8.5 Gbps), the "window" for valid data (called a bit period) decreases proportionally to the speed. As shown in table 1, the bit period for FC at a 1G data rate is 941 picoseconds, whereas it falls to 235 picoseconds at 4G and only 118 picoseconds at 8G.

Fibre Channel Data Rates (Gbps)	Bit Period (picoseconds)
1G	941
2G	471
4G	235
8G	118

Table 1: Bit Period at FC Data Rates

In the figures below, the eye diagrams for 2G and 4G FC infrastructures illustrate this phenomenon of reduced "optical eye" or "window" for valid data at 4G/s data rates.

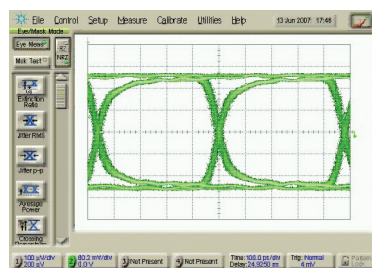


Figure 1: Eye Diagram for 2G data rate

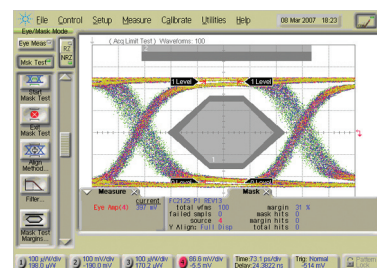


Figure 3: Eye Diagram for 2G data rate

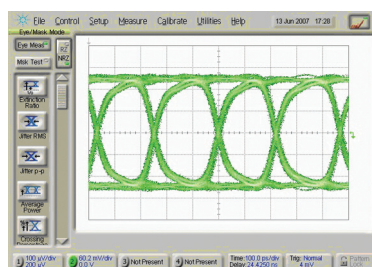


Figure 2: Eye Diagram for 4G data rate

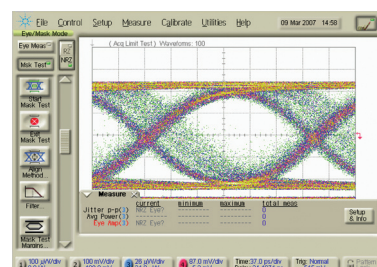


Figure 4: Eye Diagram for 4G data rate

This reduction of the “eye” requires a more robust infrastructure. Otherwise, the cabling and communications infrastructure may induce errors into the bit stream, leading to increased bit-error rates and costly transmission faults, causing retries or other performance-damaging consequences, and potential application disruptions.

When switching from 2G to 4G infrastructures, even well-performing 2G environments might quickly encounter unexpected failures running at 4G. The diagrams below show how the infrastructure-induced jitter component impacts 2G and 4G infrastructures. The only difference between the following diagrams is the data rate. In Figure 3, the 2G eye shows that the induced jitter reduces the mask margin, but is still quite acceptable. On the other hand, by increasing the bit rate (decreasing the bit time) the associated jitter becomes more dominant and creeps into the eye mask zone, which can cause system errors (see Figure 4).

Jitter, which exists in varying degrees in all optical infrastructures, can result from any component within the infrastructure, including the quality of the optical transceivers, length and quality of fiber optic cables, quantity of in-line connectors, bend radius of the cables, and even the cleanliness of the cable junctions. For example: a small speck of dirt on the face of the optical cable junction, transparent at 2G, becomes a major error-inducer at 4G slowing down critical applications.

Implications on the SAN infrastructure

Even if the network performed flawlessly at 2G, that does not guarantee the same result at 4G. As described above, an infrastructure running at 4G has a much higher sensitivity to induced jitter from dirty connections, excessive cable bend, poor quality SFP's, and other issues inherent to the infrastructure itself. A light budget and error-analysis exercise is a best practice to test and ensure the existing infrastructure can support the new data rates. In extreme cases, new fiber optic cabling may be necessary to remedy any faulty infrastructure.

Furthermore, once an infrastructure has been equipped to operate at the new higher speed, it may not remain error-free over a period of time. New cable installations, the addition of patch panels, or even slight adjustments made with existing cable routings can significantly increase jitter and reduce overall link performance. Extreme care must be taken to ensure links are as clean as possible, cables are not bent too much, and cable length and the number of connections are within the budget, preventing any foreign particles from deflecting light or excessive light loss as the light traverses the network.

Unfortunately, when these transmission errors are present (but while their true root cause remains unknown), network administrators often rely on “rip-and-replace” tactics in the hope that this will remove the offending component. Or worse, the root cause is assumed to be other SAN elements like host bus adapters (HBAs), and these are replaced unnecessarily. Not only is this expensive and extremely disruptive to the data center and to the critical applications, it often does not remedy the problem. The problem may disappear temporarily, providing a false sense of security, only to re-surface again without warning or apparent cause. This leads to endless fire-fighting and wasted time that could be applied to higher-value activities.

Best practices to ensure smooth transition and optimal performance

To ensure a smooth transition from 2G infrastructures to 4G infrastructures, network administrators should follow the best practices listed below.

1. Clean the optical modules, connectors and the cable junctions. Ensuring that there is no contamination in the fiber optic connections is very critical for the proper operation of the infrastructure. Optics-grade solvents, cleaning sticks and lint-free swabs are available from many different manufacturers that are engineered specifically for removing microscopic particles and trace oils from optics.
2. Perform an optical power budget analysis between transmit and receive ports. Make sure that the Power margin (transmit power – power loss due to the length of the cable and the connectors between the two ports) is above the required receive power of the optical transceivers and meets the FC protocol specification.
3. Measure the light levels on the transmit side and receive side. Using light testers or light meters, available from various manufacturers, measure the optical power levels on critical links and make appropriate adjustments to the length of the cables or bend radii of the cables. In some cases better quality optical transceivers or cables may be necessary to meet the power margin requirements.

There is no technique to ensure that every link remains error-free over the long term, but by instrumenting and monitoring the physical layer links, users concerns with the robustness of the links in operation can be alleviated. By installing passive devices called TAPs (Traffic Analysis Points), the quality of the physical links may be continuously monitored for error conditions and any anomalies will be automatically reported to the IT staff at the first indication of link failures. TAPs are completely passive and do not introduce a point of failure within the network.

With TAPs installed on all key links within the data center, users can deploy a number of devices that monitor and diagnose link performance without any further interruption or downtime. These devices, which include light meters, link probes, and protocol analyzers, are engineered to detect a number of issues such as light levels, signal quality, throughput metrics, latency and response times, and protocol violations. These metrics provide a good indication of the health of the infrastructure and identify failing devices or bad links – all in real-time and at full line speed. An instrumented infrastructure takes the guesswork out of understanding optical link health, providing accurate visibility into the infrastructure operation.

This real-time visibility into infrastructure is extremely important as data rates increase from 2G to 4G to 8G and 10G rates. TAPs empower the SAN to provide uninterrupted access to business critical application data.

Summary

Transitioning your storage infrastructure to higher data rates has many benefits. However, it is paramount to understand the hidden pitfalls that may impact application performance and availability. By following the best practices described in this paper, including the use of TAPs to instrument the optical links you can ensure smooth deployments and optimal operations of your SAN.

Test & Measurement Regional Sales

NORTH AMERICA TEL: 1 888 746 6484 sales-snt@jdsu.com	ASIA PACIFIC apacsales-snt@jdsu.com	EMEA emeasales-snt@jdsu.com	WEBSITE: www.jdsu.com/snt
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